ASA-481-05

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Accompanying Continuation Application under
37 CFR 1.53(b):

Prior Application:	N. HASEGAWA et al Serial No. 08/904,754 Filed: August 1, 1997
Group Art Unit:	1752
Examiner:	S. Rosasco
For:	PHOTOMASK AND PATTERN FORMING METHOD EMPLOYING THE SAME

REQUEST FOR CONTINUATION APPLICATION UNDER 37 C.F.R. 1.53(b)

Assistant Commissioner of Patents
Washington, D.C. 20231

November 10, 1998

Sir:

This is a request for filing a continuation application under 37 C.F.R. 1.53(b) of pending prior application Serial No. 08/904,754, filed on August 1, 1997, entitled PHOTOMASK AND PATTERN FORMING METHOD EMPLOYING THE SAME, by all of the inventors named in the prior application.

1. Enclosed is a copy of the prior application, including the Declaration as originally filed.

2. The Filing Fee is calculated below:

CLAIMS AS FILED IN THE PRIOR APPLICATION LESS ANY CLAIMS CANCELED BY AMENDMENT BELOW PLUS ANY CLAIMS ADDED BY ACCOMPANYING PRELIMINARY AMENDMENT

Basic Fee										$ 790.00
Total Claims	37	-	20	=	17	x	22	=		$ 374.00
Independent Claims	10	-	3	=	7	x	82	=		$ 574.00
Total Filing Fee										$1738.00

3. A check including the amount of $1738.00 is enclosed to cover the Filing Fee and Additional Claims.

4. Cancel claims 2-9 before calculating the Filing Fee.

5. The Commissioner is hereby authorized to charge any additional fees which may be required, or to credit any overpayment, to Deposit Account No. 02-1540. A duplicate copy of this Request is enclosed for this purpose.

6. Amend the specification by inserting, before the first line:

--This is a continuation application of U.S. Serial No. 08/904,754, filed August 1, 1997, which is a continuation application of U.S. Serial No. 08/699,732, filed August 20, 1996, now U.S. Patent No. 5,656,400, which is a continuation application of U.S. Serial No. 08/418,402, filed April 7, 1995, now U.S. Patent No. 5,578,421, which is a divisional application of U.S. Serial No. 08/162,319, filed December 7, 1993, now U.S. Patent No. 5,429,896.--.

7. New drawings are enclosed, four (4) sheets, Figs. 1A-6D.

8. The power of attorney in the prior application is to:

Thomas E. Beall, Jr., Registration No. 22,410
Jeffrey M. Ketchum, Registration No. 31,174
Shrinath Malur, Registration No. 34,663
John R. Mattingly, Registration No. 30,293
Daniel J. Stanger, Registration No. 32,846
Gene W. Stockman, Registration No. 21,021.

The power is combined with the Declaration and appears in the originally filed papers of the prior application.

Address all future correspondence to:

FAY, SHARPE, BEALL, FAGAN, MINNICH & McKEE
104 East Hume Avenue
Alexandria, Virginia 22301
(703) 684-1120.

9. The prior application is assigned to Hitachi, Ltd.

10. Priority of the following Japanese patent application is claimed under 35 U.S.C. § 119:

No. 4-326433, filed December 7, 1992.

The certified priority document was filed during prosecution of USSN 08/162,319.

The undersigned hereby declares and verifies that the enclosed application is a true copy of the latest signed prior application Serial No. 08/904,754, as originally filed on August 1, 1997, and no amendment referred to in the declaration filed to complete the prior application introduced new matter into the prior application.

The undersigned declares further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under

Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

Daniel J. Stanger
Registration No. 32,846
Attorney of Record

FAY, SHARPE, BEALL,
FAGAN, MINNICH & McKEE
104 East Hume Avenue
Alexandria, Virginia 22301
(703) 684-1120
Date: November 10, 1998

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For:	PHOTOMASK AND PATTERN FORMING METHOD EMPLOYING THE SAME

PRELIMINARY AMENDMENT

Assistant Commissioner of Patents
Washington, D.C. 20231

November 10, 1998

Sir:

Prior to examination, please amend the above application as follows.

IN THE SPECIFICATION

Please amend the specification as set forth below.

Page 1, line 11, change "size" to --sizes--;

line 17, change "one of" to --a--; and

line 18, change "portions on" to --portion on one of--.

Page 2, line 9, change "a little quantity of" to --some of the--;

line 10, change "is" to --are--;

line 22, change "is" to --are--; and

line 27, delete "an" (second occurrence).

Page 3, line 3, after "transmittance." begin a new paragraph;

line 7, after "that" insert --,--;

line 8, change "is" to --are--;

line 11, change "cancels" to --cancel--; and

line 15, change "the intensity" to --be--.

Page 4, line 1, change "beams the" to --beams, which have an--;

line 2, change "of which" to --that--;

line 3, change "photoresist," to --photoresist--;

line 4, after "transferred" insert --,--;

line 6, change "is" to --are--;

line 13, change "period division-A new technique" to --Period Division-A New Technique--;

line 14, change this entire line to read --Exposing Submicrometer-Linewidth Periodic and Quasi- --;

line 15, change "patterns"" to --Patterns"--;

line 21, delete "the" (second occurrence);

line 25, delete "the" (second occurrence); and

line 26, change "step and repeat" to --step-and-repeat exposure --.

Page 5, line 3, delete "the";

line 7, delete "the";

line 8, change "step and repeat" to --step-and-repeat exposure--;

line 18, after "to" insert --obtain--; and

line 19, change "of" to --for--.

Page 6, line 1, change "becomes" to --become--; and

line 22, change "Mbits-DRAM" to --Mbit DRAM--.

Page 7, line 12, change "zero. This reason is that" to --zero because,--;

line 16, delete "cancelling";

line 17, after "beams" insert --canceling--;

line 25, change "water" to --wafer--; and

line 26, change "step and repeat" to --step-and-repeat process--.

Page 8, line 8, before "Incidentally," begin a new paragraph.

Page 9, line 17, after "resolution." begin a new paragraph;

line 19, delete "the" (second occurrence); and

line 24, before "The" begin a new paragraph.

Page 10, between lines 7 and 8, after "NA" insert --,--;

line 8, delete ",";

line 11, before "In" begin a new paragraph;

line 13, change "larger" to --smaller--;

line 17, change "A" to --The--; and after "like." begin a new paragraph;

line 22, change "Then, the" to --The--;

line 24, delete "along a line"; and

line 25, delete "A-B".

Page 11, line 2, after "pitch." begin a new paragraph;

line 16, after "found." begin a new paragraph;

between lines 21 and 22, after "T" insert --,--;

line 19, delete "for the";

line 20, delete "formation of the dark portion";

line 22, delete ","; and

line 25, after "on" insert --the--; and change "purposes" to --purpose--.

Page 12, line 2, delete "an intensity which";

line 3, delete "is"; and change "having" to --which has--;

line 6, change "pattern containing" to --pattern-containing--;

line 12, after "2.0." begin a new paragraph;

line 16, change "step and repeat" to --step-and-repeat process--; and change "the" (second occurrence) to --a--;

line 18, delete "occurrence of the";

line 19, delete "the" (first occurrence); and

line 20, before "As" begin a new paragraph.

Page 13, line 2, change "an expression of" to --the expression--;

line 5, change "the substantially" to --substantially the--;

line 6, after "obtained." begin a new paragraph;

line 7, delete "the dark portion which is formed by";

line 9, delete "the" (second occurrence);

line 10, change "prevention of" to --prevent--, and change "the" (second occurrence) to --this--;

line 11, delete "of the dark portion";

line 13, change "dark portion" to --combination--;

line 17, after "area" insert --,--, and change "dark" to --light shielding--;

line 18, delete "dark";

line 19, before "portion" insert --light shielding--, and delete "the"; and

line 25, change "Mbits-" to --Mbit--.

Page 14, line 6, after "arranged" insert --,--;

line 7, after "device." begin a new paragraph;

line 8, delete "dark";

line 9, change "area 6" to --pattern configuration 6' of light shielding portion 6--; and change "step" to --step- --;

line 10, change "and repeat" to --and-repeat process--;

line 16, delete "to the";

line 17, delete "position";

line 21, change "dark" to --pattern configuration 6'--;

line 24, change "the about" to --about the--;

line 25, change "dark portion" to --pattern configuration 6'--;

line 26, change "the three portions" to --three--; and change "are made" to --have--; and

line 27, change "dark portions" to --pattern configurations--.

Page 15, line 2, change "Mbits-DRAM, the" to --Mbit DRAM,--;

line 4, change "the" to --a--;

line 6, delete "dark";

line 7, change "portion" to --pattern configuration 6'--;

line 9, change "the" to --a--;

line 10, delete "dark";

line 11, change "portion" to --pattern configuration 6'--;

line 18, after "position." begin a new paragraph;

line 19, change "the" (first occurrence) to --a--;

line 22, delete "along a line A-B";

line 26, change "in the" to --with a--;

line 27, change "judgement" to --judgment--; and

line 28, change "dark portion" to --light shielding pattern configuration--.

Page 16, line 4, after "portion" insert --,--;

line 17, after "20." begin a new paragraph;

line 19, change "Next," to --Then,--;

line 20, delete "then";

line 22, before "Next," begin a new paragraph;

line 23, delete "the";

line 24, delete "technique";

line 26, change "Next," to --Then,--;

line 27, delete "then"; and

line 28, change "dark portion" to --light shielding pattern configuration--.

Page 17, line 1, after "is" insert --also--; and before "Next," begin a new paragraph;

line 2, change "the" to --a--;

line 7, change "the following" to --a subsequent--;

line 8, after "employed." begin a new paragraph;

line 15, after "LSI" insert --chips--;

line 22, delete "in";

line 23, change "the" (second occurrence) to --a practical--;

line 24, delete "which is useful in practical use"; and

line 27, change "the" to --a--.

Page 18, line 7, change "changed" to --changes--.

IN THE CLAIMS

After granting a filing date to this continuation application, please cancel claim 1 and add new claims 10-46 as set forth below.

--10. A pattern forming method comprising the steps of:

preparing a semitransparent phase shifting mask including (a) a semitransparent phase shifting pattern formed at a predetermined position on a photomask substrate and (b) a light shielding area provided at a peripheral edge portion of said semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light shielding area smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed film; and

exposing, with a projection exposure optical system, said to-be-exposed film by use of said semitransparent phase shifting mask.

--11. A pattern forming method of comprising the steps of:

preparing a semitransparent phase shifting mask including (a) a first semitransparent phase shifting pattern having a semitransparent phase shifting film, said phase shifting film being formed at a predetermined position on a photomask substrate and having a transmittance with respect to exposure light not higher than 25% and (b) a light shielding area provided at a peripheral edge portion of said first

semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light shielding area smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed film;

preparing a substrate having a to-be-exposed film; and

exposing, with a projection exposure optical system, said to-be-exposed film to said exposure light by use of said semitransparent phase shifting mask.

--12. A method according to claim 11, said light shielding area includes a second semitransparent phase shifting pattern having a semitransparent phase shifting portion and a transparent portion, said second semitransparent phase shifting pattern being comprised of a pattern beyond a critical resolution of an exposure apparatus.

--13. A method according to claim 12, wherein a ratio α of an area of said transparent portion to an area of semitransparent phase shifting portion is defined as $\alpha = \beta\sqrt{T}$, where T represents a transmittance of said semitransparent phase shifting portion, and β represents a value in a range $0.5 \leqq \beta \leqq 2.0$.

--14. A method according to claim 11, wherein a light shielding portion is provided within a region for said first semitransparent phase shifting pattern, said light shielding portion serving to make an intensity of light having passed through said light shielding portion smaller than an intensity

of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed target.

--15. A method according to claim 11, wherein a transparent pattern is provided within said light shielding area to be transferred onto said to-be-exposed film.

--16. A method according to claim 11, wherein said first semitransparent phase shifting pattern is a pattern for forming a device.

--17. A pattern forming method comprising the steps of:

mounting a substrate having a photoresist film, on a sample stage of an aligner having a masking blade;

mounting, on a mask support of said aligner, a semitransparent phase shifting mask including (a) a semitransparent phase shifting pattern formed at a predetermined position on a photomask substrate and (b) a light shielding area provided at a peripheral edge portion of said semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light shielding area smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on said photoresist film; and

exposing said photoresist film by use of said semitransparent phase shifting mask.

--18. A pattern forming method comprising the steps of:

mounting a substrate having a to-be-exposed film, on a sample stage of an aligner having a masking blade;

mounting, on a mask support of said aligner, a semitransparent phase shifting mask including (a) a first semitransparent phase shifting pattern having a semitransparent phase shifting film, said phase shifting film being formed at a predetermined position on a photomask substrate and having a transmittance with respect to exposure light not higher than 25% and (b) a light shielding area provided at a peripheral edge portion of said first semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed film;

exposing a first area of said to-be-exposed film by use of said semitransparent phase shifting mask;

moving said sample stage in a horizontal direction; and exposing a second area, different from said first area, of said to-be-exposed film by use of said semitransparent phase shifting mask.

--19. A method according to claim 18, wherein said light shielding area includes a second semitransparent phase shifting pattern having a semitransparent phase shifting portion and a transparent portion, said second semitransparent phase shifting pattern being comprised of a pattern beyond a critical resolution of an exposure apparatus.

--20. A method according to claim 19, wherein a ratio α of an area of said transparent portion to an area of semitransparent phase shifting portion is defined as $\alpha = \beta\sqrt{T}$, where T represents a transmittance of said semitransparent phase shifting portion, and β represents a value in a range $0.5 \leqq \beta \leqq 2.0$.

--21. A method according to claim 18, wherein a light shielding portion is provided within a region for said first semitransparent phase shifting pattern, said light shielding portion serving to make an intensity of light having passed through said light shielding portion smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed film.

--22. A method according to claim 18, wherein a transparent pattern is provided within said light shielding area to be transferred onto said to-be-exposed film.

--23. A method according to claim 18, wherein said first semitransparent phase shifting pattern is a pattern for forming a device.

--24. A method according to claim 18, wherein said second area includes a portion of said to-be-exposed film which is shielded by said light shielding area in said step of exposing said first area of said to-be-exposed film.

--25. A method of manufacturing a semiconductor device, comprising the steps of:

preparing a semitransparent phase shifting mask including (a) a first semitransparent phase shifting pattern for formation of a semiconductor device having a semitransparent phase shifting film, said phase shifting film being formed at a predetermined position on a photomask substrate and having a transmittance with respect to exposure light not higher than 25% and (b) a light shielding area provided at a peripheral edge portion of said first semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light shielding area smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed film;

preparing a substrate having a to-be-exposed film; and

exposing, with a projection exposure optical system, said to-be-exposed film to said exposure light by use of said semitransparent phase shifting mask.

--26. A method according to claim 25, wherein said light shielding area includes a second semitransparent phase shifting pattern having a semitransparent phase shifting portion and a transparent portion, said second semitransparent phase shifting pattern being comprised of a pattern beyond a critical resolution of an exposure apparatus.

--27. A method according to claim 26, wherein a ratio α of an area of said transparent portion to an area of semitransparent phase shifting portion is defined as $\alpha = \beta\sqrt{T}$, where T represents a transmittance of said semitransparent phase shifting portion, and β represents a value in a range $0.5 \leqq \beta \leqq 2.0$.

--28. A method according to claim 25, wherein a light shielding portion is provided within a region for said first semitransparent phase shifting pattern, said light shielding portion serving to make an intensity of light having passed through said light shielding portion smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed target.

--29. A method according to claim 25, wherein a transparent pattern is provided within said light shielding area to be transferred onto said to-be-exposed film.

--30. A method of manufacturing a semiconductor device, comprising the steps of:

mounting a substrate having a to-be-exposed film, on a sample stage of an aligner having a masking blade;

mounting, on a mask support of said aligner, a semitransparent phase shifting mask including (a) a first semitransparent phase shifting pattern for formation of a semiconductor device having a semitransparent phase shifting film, said phase shifting film being formed at a predetermined position on a photomask substrate and having a transmittance

with respect to exposure light not higher than 25% and (b) a light shielding area provided at a peripheral edge portion of said first semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light shielding area smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed film;

exposing a first area of said to-be-exposed film by use of said semitransparent phase shifting mask;

moving said sample stage in a horizontal direction; and

exposing a second area, different from said first area, of said to-be-exposed film by use of said semitransparent phase shifting mask.

--31. A method according to claim 30, said light shielding area includes a second semitransparent phase shifting pattern having a semitransparent phase shifting portion and a transparent portion, said second semitransparent phase shifting pattern being comprised of a pattern beyond a critical resolution of an exposure apparatus.

--32. A method according to claim 31, wherein a ratio α of an area of said transparent portion to an area of semitransparent phase shifting portion is defined as $\alpha = \beta\sqrt{T}$, where T represents a transmittance of said semitransparent phase shifting portion, and β represents a value in a range $0.5 \leqq \beta \leqq 2.0$.

--33. A method according to claim 31, wherein a light shielding portion is provided within a region for said first semitransparent phase shifting pattern, said light shielding portion serving to make an intensity of light having passed through said light shielding portion smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed target.

--34. A method according to claim 31, wherein a transparent pattern is provided within said light shielding area to be transferred onto said to-be-exposed film.

--35. A method of manufacturing a semiconductor device, comprising the steps of:

forming an impurity-doped layer in a predetermined region of a semiconductor substrate;

forming an insulating film on said semiconductor substrate having said doped layer formed therein;

forming a photoresist film on said insulating film;

mounting said substrate having said photoresist film, on a sample stage of an aligner having a masking blade;

mounting, on a mask support of said aligner, a semitransparent phase shifting mask including (a) a first semitransparent phase shifting pattern for formation of a hole having a semitransparent phase shifting film, said phase shifting film being formed at a predetermined position on a photomask substrate and having a transmittance with respect to exposure light not higher than 25% and (b) a light shielding

area provided at a peripheral edge portion of said first semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light shielding area smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on said photoresist film; and

exposing a first area of said photoresist film by use of said semitransparent phase shifting mask;

moving said sample stage in a horizontal direction;

exposing a second area, different from said first area, of said photoresist film by use of said semitransparent phase shifting mask; and, thereafter

etching said insulating film to form a hole above said impurity doped layer.

--36. A method of manufacturing a semiconductor device, comprising the steps of

forming a wiring layer above a predetermined region of a semiconductor substrate;

forming an insulating film on said semiconductor substrate having said wiring layer formed thereabove;

forming a photoresist film on said insulating film;

mounting said substrate having said photoresist film, on a sample stage of an aligner having a masking blade;

mounting, on a mask support of said aligner, a semitransparent phase shifting mask including (a) a first semitransparent phase shifting pattern for formation of a hole

having a semitransparent phase shifting film, said phase shifting film being formed at a predetermined position on a photomask substrate and having a transmittance with respect to exposure light not higher than 25% and (b) a light shielding area provided at a peripheral edge portion of said first semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light shielding area smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on said photoresist film; and

exposing a first area of said photoresist film by use of said semitransparent phase shifting mask;

moving said sample stage in a horizontal direction;

exposing a second area, different from said first area, of said photoresist film by use of said semitransparent phase shifting mask; and, thereafter

etching said insulating film to form a hole above said wiring layer.

--37. A method of manufacturing a semiconductor device, comprising the steps of:

preparing a semitransparent phase shifting mask including (a) a first semitransparent phase shifting pattern for formation of a semiconductor device having a semitransparent phase shifting film, said phase shifting film being formed at a predetermined position on a photomask substrate and having a transmittance with respect to exposure light not higher than

25% and (b) a light shielding area provided at a peripheral edge portion of said first semitransparent phase shifting pattern;

preparing a substrate having a to-be-exposed film, said light shielding area of said semitransparent phase shifting mask serving to make an intensity of light having passed through said light shielding area not larger than 0.05, as measured on said to-be-exposed film; and

exposing, with a projection exposure optical system, said to-be-exposed film to said exposure light by use of said semitransparent phase shifting mask.

--38. A method according to claim 37, said light shielding area includes a second semitransparent phase shifting pattern having a semitransparent phase shifting portion and a transparent portion, said second semitransparent phase shifting pattern being comprised of a pattern beyond a critical resolution of an exposure apparatus.

--39. A method according to claim 38, wherein a ratio α of an area of said transparent portion to an area of semitransparent phase shifting portion is defined as $\alpha = \beta\sqrt{T}$, where T represents a transmittance of said semitransparent phase shifting portion, and β represents a value in a range $0.5 \leqq \beta \leqq 2.0$.

--40. A method according to claim 37, wherein a light shielding portion is provided with a region for said first semitransparent phase shifting pattern, said light shielding

portion serving to make an intensity of light having passed through said light shielding portion smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed target.

--41. A method according to claim 37, wherein a transparent pattern is provided within said light shielding area to be transferred onto said to-be-exposed film.

--42. A method of manufacturing a semiconductor device, comprising the steps of:

mounting a substrate having to-be-exposed film, on a sample stage of an aligner having a masking blade;

mounting, on a mask support of said aligner, a semitransparent phase shifting mask including (a) a first semitransparent phase shifting pattern for formation of a semiconductor device having a semitransparent phase shifting film, said phase shifting film being formed at a predetermined position on a photomask substrate and having a transmittance with respect to exposure light not higher than 25% and (b) a light shielding area provided at a peripheral edge portion of said first semitransparent phase shifting pattern and serving to make an intensity of light having passed through said light shielding area not larger than 0.05, as measured on said to-be-exposed film;

exposing a first area of said to-be-exposed film by use of said semitransparent phase shifting mask;

moving said sample stage in a horizontal direction;

exposing a second area, different from said first area, of said to-be-exposed film by use of said semitransparent phase shifting mask.

--43. A method according to claim 42, said light shielding area includes a second semitransparent phase shifting pattern having a semitransparent phase shifting portion and a transparent portion, said second semitransparent phase shifting pattern being comprised of a pattern beyond a critical resolution of an exposure apparatus.

--44. A method according to claim 43, wherein a ratio α of an area of said transparent portion to an area of semitransparent phase shifting portion is defined as $\alpha = \beta\sqrt{T}$, where T represents a transmittance of said semitransparent phase shifting portion, and β represents a value in a range $0.5 \leqq \beta \leqq 2.0$.

--45. A method according to claim 43, wherein a light shielding portion is provided within a region for said first semitransparent phase shifting pattern, said light shielding portion serving to make an intensity of light having passed through said light shielding portion smaller than an intensity of light having passed through said semitransparent phase shifting film, as measured on a to-be-exposed target.

--46. A method according to claim 43, wherein a transparent pattern is provided within said light shielding area to be transferred onto said to-be-exposed film.--

REMARKS

Examination of the foregoing claims is requested.

Respectfully submitted,

Daniel J. Stanger
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Attorney for Applicants

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Date: November 10, 1998

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates to a photomask which is used to manufacture a semiconductor device and the like, and more particularly to a photomask which has been subjected to a processing of shifting a phase of exposure light beams and a pattern forming method employing the same.

Along with an increase of the integration scale for semiconductor devices, sizes of patterns for forming constituent elements of the devices become fine, and size equal to or smaller than the critical resolution of a projection aligner are required. As a method of fulfilling such a request, in JP-B-62-50811 published on October 27, 1987, and corresponding to JP-A-57-62052 (laid open on April 14, 1982) for example, a photomask is employed in which a transparent film for shifting a phase of exposure light beams is provided on one of transparent portions on the opposite sides sandwiching an opaque portion, and thus the resolution of a pattern is exceptionally improved.

In the above-mentioned prior art, a phase shifter needs to be arranged in one of the transparent portions adjacent to each other, and for the arrangement of the phase shifter in the complicated element pattern, high trial and error is necessarily required. Thus,

there is required considerable labor. In addition, since the number of processes of manufacturing a photomask is doubled as compared with the prior art, the reduction in yield and the increase in cost become problems.

Those problems can be settled by employing a semitransparent phase shifting mask in which a semi-transparent portion and a transparent portion are provided, and a little quantity of light beams passed through the semitransparent portion is phase-inverted with respect to light beams having passed through the transparent portion. With respect to this point, the description will hereinbelow be given with reference to the accompanying drawings.

FIG. 1A is a cross sectional view showing a structure of an example of a semitransparent phase shifting mask. In the figure, reference numeral 1 designates a transparent substrate, and reference numeral 2 designates a semitransparent film. A thickness of the semitransparent film 2 is adjusted such that the light beams having passed through the trans-parent portion 3 is phase-inverted with respect to the light beams having passed through a semitransparent portion 4. The semitransparent film 2 has a trans-mittance such that a light beam having passed through the transparent substrate 1 and the semitransparent film 2 has an intensity high enough to cause an interference with a light beam having passed through the transparent

substrate 1. The transparent film used in this specification means a film having the above-mentioned transmittance. The light intensity distribution of the projected light beams on a wafer becomes, as shown in FIG. 1B, a sharp light intensity distribution. The reason such a sharp light intensity distribution is obtained is that since the light beams having passed through the transparent portion is phase-inverted with respect to the light beams having passed through the semitransparent portion, the former and the latter cancels each other in a boundary portion of the pattern so that the light intensity becomes approximately zero. In addition, since the intensity of the light beams having passed through the semitransparent portion is adjusted to the intensity equal to or lower than the sensitivity of a photoresist, the intensity of the light beams having passed through the semitransparent portion is not an obstacle to the formation of the pattern. That is, in this method, since the phase inversion effect between the pattern to be transferred and the semitransparent portion therearound is utilized, there is no need to take, as in the normal phase shifting mask, the arrangement of the phase shifter into consideration. In addition, in the prior art phase shift mask, the two lithography processes are required for the formation of the mask. However, in this method, one lithography process has only to be performed. Thus, it is possible to form the mask very simply.

In this method, the light beams the intensity of which is equal to or lower than the sensitivity of a photoresist, to which the pattern of the mask is to be transferred are made to pass through the semitransparent film so that the light beams which have passed through the semitransparent film is phase-inverted with respect to the light beams which have passed through the transparent portion, and thus, the contrast of the pattern is improved. As a result, it is possible to improve the resolution of an aligner for transferring the mask pattern. The basic principle of the semitransparent phase shifting mask is described in D. C. Flanders et al.: "Spatial period division-A new technique for exposing submicrometer-linewidth periodic and quasi-periodic patterns" J. Vac. Sci. Technol., 16(6), Nov./Dec. pp 1949 to 1952 (1979), U. S. Patent Nos. 4,360,586 and 4,890,309 and JP-A-4-136854 (laid open on May 11, 1992).

In the lithography process in which the above-mentioned semitransparent phase shifting mask is employed, in the normal exposed area, the good pattern formation can be performed. However, it has been made clear by the investigations made by the present inventors that since in the actual exposure of the wafer, the mask pattern is repeatedly transferred by the step and repeat, the light beams which have leaked from the semitransparent area, which is located outside the periphery of the actual pattern element corresponding to

an active region of a substrate, leak out to the adjacent exposed area, and thus this is an obstacle to the good pattern formation.

It is therefore an object of the present invention to provide a photomask by which a good pattern can be obtained even in the case of an exposure, in which a mask pattern is repeatedly transferred by the step and repeat, and a pattern forming method employing the same.

According to one aspect of the present invention, the above-mentioned object can be attained by effectively making a light-shielding or opaque area of a semitransparent phase shift mask which is located outside the periphery of a pattern element formation area of the semitransparent phase shifting mask.

The light shielding portion in the semitransparent phase shifting mask is formed by processing a semitransparent film to a pattern having a width equal to or lower than the resolution. The reason of adopting such a method is that if a light shielding film is newly formed as the light shielding portion, this will result in an increase of the number of processes of forming the mask. Incidentally, by optimizing the area ratio of the semitransparent portion to the transparent portion, it is possible to further effectively form the light shielding portion.

These and other objects and many of the attendant advantages of the invention will be readily

appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are respectively a cross-sectional view showing a structure of a semitransparent phase shifting mask, and a view showing the light intensity distribution of projected light beams on a wafer when using the mask shown in FIG. 1A.

FIGS. 2A and 2B are respectively a plan view and a cross sectional view each showing a structure of a photomask according to the present invention.

FIG. 3A is a plan view showing a structure of a light shielding portion of the photomask according to the present invention.

FIG. 3B is a graphical representation showing the relationship between the size of a transparent pattern of the photomask according to the present invention and the intensity of projected exposure light beams.

FIG. 4 is a plan view showing a structure of a mask for forming contact holes of a 64 Mbits-DRAM according to the present invention.

FIGS. 5A and 5B are respectively a plan view showing a structure of a window pattern portion for aligning the position of the mask according to the present invention, and a view showing the light

intensity distribution of the projected light beams on the wafer when using the mask shown in FIG. 5A.

FIGS. 6A through 6D are cross sectional views showing steps of a process of manufacturing a semiconductor device according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

When both a semitransparent phase shifting pattern and a transparent pattern are arranged with the same size and at a pitch equal to or lower than the critical resolution, a pattern image can be erased. But, in this case, the resulting uniform light intensity does not become zero. This reason is that since there is a difference between the quantity of light beams having passed through the semitransparent phase shifting portion and that of light beams having passed through the transparent portion, the function of cancelling those light beams each other due to the phase inversion effect is not efficiently performed.

Then, when the ratio of the area of the semitransparent phase shifting portion to that of the transparent portion is adjusted in accordance with a set transmittance of the semitransparent phase shifting portion, it is made clear that the light intensity can be zero. By using this pattern for an area of a to-be-exposed water surface, which may be otherwise undesirably double-exposed by the step and repeat by an aligner, it is possible to prevent the double exposure

on the wafer, and a pattern of constituent elements as desired can be formed. Therefore, since the present photomask is made up of only semitransparent phase shifting portions and transparent portions, there is no need to newly form a light shielding film for the formation of the light shielding portion, and thus, the process of forming the photomask can be simplified. Incidentally, the above-mentioned light shielding portion is applicable to the formation of a light shielding portion in a pattern element region of a substrate. In this case, since the ratio of the transmittance of the transparent portion to that of the light shielding portion can be made large, it is possible to increase the tolerance for the variation of the quantity of light beams required for the exposure.

As for the materials used for the formation of the semitransparent phase shifting portion, a lamination film of a semitransparent metal film (made of chromium, titanium or the like) or a silicide film (e.g., a molybdenum silicide film) and a silicon oxide film for the phase shift, or a single layer film such as a metal oxide film (e.g., a chromium oxide film) or metal nitride film (e.g., a chromium nitride film) may be employed. In the case where a single layer film such as a chromium oxide film or a chromium nitride film is employed, since the refractive index thereof is larger than that of the silicon oxide film, the film can be thinned. As a result, since the influence of the light

diffraction can be reduced, this single layer film is suitable for the formation of a fine pattern.

Embodiment 1

A first embodiment of the present invention will hereinafter be described in detail. FIGS. 2A and 2B are respectively a plan view and a cross sectional view each showing the appearance of a photomask employed in the present embodiment. In those figures, reference numeral 1 designates a transparent substrate, and reference numeral 5 designates an element pattern portion in which both a semitransparent phase shifting portion and a transparent portion are arranged. Moreover, reference numeral 6 designates a portion acting, on a wafer, as a light shielding portion in which semitransparent phase shifting patterns are arranged at a pitch equal to or smaller than the resolution. Reference numeral 7 designates a masking blade for shielding, on the aligner side, the exposure light beams. Since the masking blade 7 is poor in the positional accuracy, it is positioned so as to shield the light beams passing through the portion which is located outside the intermediate position of the width of the area 6 acting as the light shielding portion. The details of the area 6 acting as the light shielding portion will hereinbelow be described with reference to FIGS. 3A and 3B. FIG. 3A is a plan view showing a structure of a pattern. In this connection, each

transparent pattern portion 10 is formed within a semitransparent phase shifting portion 9. An arrangement pitch 11 of the transparent patterns 10 is determined depending on the resolution characteristics of the projection optical system employed. The arrangement pitch P is expressed by the following expression:

$$P = \alpha \cdot \lambda / NA$$

, where NA represents a numerical aperture of a projection lens, λ represents a wavelength of the exposure light beams, and α represents a coefficient. In this connection, on the basis of the experiments made by the present inventors, it is desirable that the coefficient α is set to a value equal to or larger than 0.8. However, the optimal value of α is not limited thereto or thereby because the optimal value of α depends on the characteristics of the illuminating system, the pattern configuration and the like. A width 12 of the transparent pattern 10 influences largely the formation of a dark portion. FIG. 3B shows the intensity of the projected light beams which is obtained on the wafer when changing the width 12 of the transparent pattern 10. Then, the intensity of the projected light beams shows the intensity of the light beams which have passed through the pattern along a line A-B of FIG. 3A. The pitch of the transparent patterns

10 was determined to be 0.4 μm by using $\alpha = 0.1$ in the expression of the arrangement pitch. With respect to the three kinds of transmittance 9 %, 16 % and 25 % of the semitransparent phase shifting portion, the change in the intensity of the projected light beams were examined by changing the size of the transparent pattern 10. The axis of abscissa of the graph represents the size of the transparent pattern 10. From the graph of FIG. 3B, it can be seen that a minimum value is present in the intensity of the projected light beams depending on the size of the transparent pattern, and this local minimum value is variable depending on the transmittance of the semitransparent phase shifting portion. That is, it can be seen that in accordance with the transmittance of the semitransparent phase shifting portion 9, an optimal transparent pattern size can be found. Denoting the size ratio of size 12 of the transparent pattern to the size 13 of the semitransparent phase shifting portion 13 by α, an optimal value thereof for the formation of the dark portion will be expressed by the following expression:

$$\alpha = \beta \cdot \sqrt{T}$$

, where T represents a transmittance of the semitransparent phase shifting portion, and β represents a coefficient. The allowable intensity of the projected light beams is variable depending on intended purposes. In the case of preventing exposure of a photoresist due

to a double exposure, the allowable intensity of the projected light beams may be set to an intensity which is about one-half the intensity of light having passed through the semitransparent phase shifting portion. However, in the case of preventing a double exposure of a dark portion with a fine pattern containing portion, the change in the size of the fine pattern needs to be reduced as much as possible, and thus it is desirable that the allowable intensity of the projected light beams is set to a value equal to or lower than 0.05. The value of β in this case is in the range of about 0.5 to about 2.0. Then, the area 6 of FIG. 2A was formed on the basis of the optimal conditions thus obtained, and by actually using the projection aligner, the pattern element 5 corresponding to the active region was exposed by the step and repeat. As a result, the good pattern element corresponding to the active region could be formed without occurrence of the pattern destruction and the size shifting even in the area in which the area 6 was doubled-exposed. As described above, the semi-transparent phase shifting portion and the transparent portion were formed with the optimal size combination, whereby the effective dark portion could be formed. Incidentally, although in the present embodiment, the example is shown in which the line transparent pattern is formed in the semitransparent phase shifting area, the present invention is not limited thereto or thereby. That is, for example, there is particularly no problem

even in the case of an island-like pattern and other patterns. In such cases, if α in an expression of $\alpha = \beta \cdot \sqrt{T}$ is replaced with the area ratio of the area of the transparent pattern to the area of the semitransparent phase shifting portion, the substantially same effects can be obtained. In addition, in the present embodiment, the dark portion which is formed by the combination of the semitransparent phase shifting pattern and the transparent pattern is applied to the prevention of the double exposure. However, the application of the dark portion of the present invention is not limited thereto or thereby. It is, of course, to be understood that the dark portion is applicable to the necessary portions such as a window pattern for aligning the mask position, a pattern for detecting the wafer position, and a semitransparent phase shifting portion having a large area all of which require a dark portion. Further, the above-mentioned photomask having a dark portion is useful for the pattern formation when manufacturing a semiconductor device.

Embodiment 2

A second embodiment of the present invention will hereinafter be described with reference to FIG. 4. FIG. 4 is a plan view showing a structure of a photomask which is used to form contact holes of a 64 Mbits-dynamic random access memory (DRAM). Two DRAM element areas 5 are arranged in a transparent substrate 1. A

scribing area 14 is provided between the two pattern element areas 5. In addition, in a peripheral scribing area 15 on two sides perpendicular to each other, a pattern for measuring the accuracy of the mask alignment, a target pattern for the mask alignment, and the like are arranged which becomes necessary for the process of manufacturing a device. In the two sides opposite to the other sides of the scribing area, a dark area 6 of the present invention is arranged. The step and repeat in the projection aligner is performed at a pitch 16 in the transverse direction and at a pitch 17 in the longitudinal direction. The peripheral portion which is located outside a dotted line 18 as the setting center is mechanically shielded from the light beams by a mechanical light shielding plate of the aligner. In this connection, the dotted line 18 is set to the position at a distance equal to or longer than the positional accuracy of the mechanical light shielding plate from the scribing area such that the mechanical light shielding plate is not shifted to the scribing area by mistake. In addition, the width of the dark portion is set to a value equal to or larger than the positional accuracy of the mechanical light shielding plate, and the dotted line 18 is arranged in the about central portion of the dark portion. Further, at least the three portions of the four corner portions are made dark portions.

As a result of using this photomask in order to manufacture the 64 Mbits-DRAM, the double exposure in the periphery of the chip can be perfectly prevented, and thus the good device can be manufactured. In addition, in the case where the pattern element area 5 is formed by one chip, or the photomask having the dark portion is applied to devices other than DRAM, the same effects can be obtained.

Further, the description will hereinbelow be given with respect to an example in which the dark portion of the present invention is arranged in the periphery of a window pattern which is used to align the mask position with reference to FIGS. 5A and 5B. FIG. 5A is a plan view showing a structure of the window pattern portion which is used to align the mask position. FIG. 5B shows the distribution of the light intensity on the wafer corresponding to the mask position. As shown in FIG. 5A, a transparent portion 10 which has the size fulfilling the conditions for forming the dark portion of FIG. 3B is formed around a window pattern 19. It can be seen that in the distribution of the light intensity on the wafer along a line A-B of the photomask of FIG. 5A at that time, the light intensity in the periphery of the window pattern is, as shown in FIG. 5B, zero, and thus signals representing the window pattern are obtained in the high signal-to-noise (S/N) ratio and the judgement of the position is performed with accuracy. In such a way, the dark portion of the

present invention is applicable to a pattern utilizing light intensity signals each having a high S/N ratio from a mask pattern and other patterns requiring the light shielding portion as well as to the light shielding in the periphery of a device chip.

Embodiment 3

Hereinbelow, an example will be shown in which a semiconductor device is manufactured according to the present invention. FIGS. 6A through 6D are cross sectional views showing steps of a process of manufacturing a semiconductor device. By using the conventional method, a P type well layer 21, a P type layer 22, a field oxide film 23, a polycrystalline Si/SiO_2 gate 24, a high impurity concentration P type diffusion layer 25, a high impurity concentration N type diffusion layer 26, and the like are formed in an N^- type Si substrate 20. Next, by using the conventional method, an insulating film 27 made of phosphor silicate glass (PSG) is deposited thereon. Next, a photoresist 28 is applied thereto, and then a hole pattern 29 is formed by using the semitransparent phase shifting mask of the present invention (refer to FIG. 6B). Next, an insulating film 27 is selectively etched by the dry etching technique with the resultant photoresist as an etching mask, thereby to form contact holes 30 (refer to FIG. 6C). Next, by using the conventional method, a W/TiN electrode wiring 31 is formed, and then an

interlayer insulating film 32 is formed. Next, a photoresist is applied thereto, and then by using the conventional method, a hole pattern 33 is formed using the semitransparent phase shifting mask of the present invention. Then, a W plug is plugged in the hole pattern 33 to connect a second level Al wiring 34 thereto (refer to FIG. 6D). In the following passivation process, the conventional method is employed. Incidentally, in the present embodiment, only the main manufacturing processes have been described. In this connection, the same processes as those of the conventional method are employed except that the semitransparent phase shifting mask of the present invention is used in the lithography process of forming the contact hole. By the above-mentioned processes, CMOS LSI can be manufactured at a high yield.

As set forth hereinabove, according to the present invention, by forming the semitransparent phase shifting portion and the transparent portion with the optimal size combination, even if a light-shielding film is not newly formed, the effective dark portion can be formed. In addition, without increasing in the number of processes of forming the mask, the semitransparent phase shifting mask which is useful in practical use can be produced. Further, as a result of manufacturing the semiconductor device by using the photomask of the present invention, it is possible to form the pattern in which the effects inherent in the semitransparent phase

shifting mask are sufficiently utilized, without any problem in the double exposure portion, and also it is possible to realize the reduction of the device area.

It is further understood by those skilled in the art that the foregoing description is a preferred embodiment of the disclosed device and that various changed and modifications may be made in the invention without departing from the spirit and scope thereof.

WHAT IS CLAIMED IS:

1. A photomask comprising:

a semitransparent phase shifting area which has a semitransparent area and a transparent area, which are respectively transparent and semitransparent with respect to exposure light beams, and in which light beams having passed through said semitransparent area is substantially 180 degrees out of phase with respect to light beams having passed through said transparent area; and

a pattern which is formed in said photomask and in which a semitransparent phase shifting pattern and a transparent pattern are arranged in a repeated pitch equal to or smaller than the critical resolution of a projection exposure optical system.

2. A photomask according to Claim 1, wherein when the repeated pitch represented by P is defined as:

$$P = \alpha \cdot \lambda / NA$$

, where NA represents a numerical aperture of a projection lens, λ represents a wavelength of the exposure light beams, and $\alpha \leq 0.8$.

3. A photomask according to Claim 1, wherein when a size ratio α of the size of said transparent pattern to the size of said semitransparent phase shifting pattern is defined as:

$$\alpha = \beta \cdot \sqrt{T}$$

, where T represents the transmittance of the semitransparent phase shifting portion, and $0.5 \leq \beta \leq 2.0$.

4. A photomask according to Claim 1, wherein when the repeated pitch P is defined as:

$$P = \alpha \cdot \lambda / NA$$

, where NA represents a numerical aperture of a projection lens, λ represents a wavelength of the exposure light beams, and $\alpha \leq 0.8$, and

when a size ratio α of the size of said transparent pattern to the size of said semitransparent phase shifting pattern is defined as:

$$\alpha = \beta \cdot \sqrt{T}$$

, where T represents the transmittance of the semitransparent phase shifting portion, and $0.5 \leq \beta \leq 2.0$.

5. A photomask according to Claim 1, wherein an area, in which the light intensity, on a projection surface, of the light beams passed therethrough is one-half or lower than that, on the projection surface, of the light beams having passed through said semitransparent phase shifting area, includes a portion corresponding to an area which is double-exposed with a projected exposure surface thereof in the step and repeat exposure.

6. A method of forming a pattern, comprising the steps of:

forming a photoresist film on a substrate;

placing said substrate having said photoresist film on a sample stage of an aligner;

exposing a predetermined first area of said substrate by using a photomask including a semitransparent phase shifting area which has a semitransparent area and a transparent area, which are respectively transparent and semitransparent with respect to exposure light beams, and in which light beams having passed through said semitransparent area is substantially 180 degrees out of phase with respect to light beams having passed through said transparent area, and a pattern which is formed in said photomask and in which a semitransparent phase shifting pattern and a transparent pattern are arranged in a repeated pitch equal to or smaller than the critical resolution of a projection exposure optical system;

moving horizontally said substrate; and

exposing a second area of said substrate which is adjacent to said predetermined first area by using said photomask.

7. A method according to Claim 6, wherein said pattern in which said semitransparent phase shifting pattern and said transparent pattern are arranged at a repeated pitch equal to or smaller than the critical resolution of said projection exposure optical system is

arranged in at least two sides which are perpendicular to each other and are located in the periphery of a pattern element area of said substrate in said photomask.

8. A method of manufacturing a semiconductor device, comprising the steps of:

forming diffusion layers in a surface of a semiconductor substrate;

forming an insulating film on said semiconductor substrate having said diffusion layers;

forming opening portions through a photoresist film on said diffusion layers by a pattern forming method, said pattern forming method including the steps of: forming said photoresist film on said insulating film; placing said substrate having said photoresist film on a sample stage of an aligner; exposing a predetermined first area of said substrate by using a photomask including a semitransparent phase shifting area which has a semitransparent area and a transparent area, which are respectively transparent and semitransparent with respect to exposure light beams, and in which light beams having passed through said semitransparent area is substantially 180 degrees out of phase with light beams having passed through said transparent area, and a pattern which is formed in said photomask and in which a semitransparent phase shifting pattern and a transparent pattern are arranged in a repeated pitch equal to or smaller than the critical resolution

of a projection exposure optical system; moving horizontally said substrate; and exposing a second area of said substrate which is adjacent to said predetermined first area by using said photomask;

etching selectively said insulating film with said photoresist film having said opening portions as a mask to expose said diffusion layers; and

forming a wiring layer, which is electrically connected to said diffusion layers, on said insulating film.

9. A method of manufacturing a semiconductor device, comprising the steps of:

forming a first insulating film on a substrate;

forming a first wiring layer on said first insulating layer;

forming a second insulating film on said substrate having said first wiring layer;

forming opening portions through a photoresist film on said first wiring layer by a pattern forming method, said pattern forming method including the steps of: forming said photoresist film on said second insulating film; placing said substrate having said photoresist film on a sample stage of an aligner; exposing a predetermined first area of said substrate by using a photomask including a semitransparent phase shifting area which has a semitransparent area and a transparent area, which are respectively transparent and

semitransparent with respect to exposure light beams, and in which light beams having passed through said semitransparent area is substantially 180 degrees out of phase with respect to light beams having passed through said transparent area, and a pattern which is formed in said photomask and in which a semitransparent phase shifting pattern and a transparent pattern are arranged in a repeated pitch equal to or smaller than the critical resolution of a projection exposure optical system; moving horizontally said substrate; and exposing a second area of said substrate which is adjacent to said predetermined first area by using said photomask;

etching selectively said second insulating film with said photoresist film having said opening portions as a mask to expose said first wiring layer; and

forming a second wiring layer, which is electrically connected to said first wiring layer, on said second insulating film.

ABSTRACT OF THE DISCLOSURE

A semitransparent phase shifting mask has, in the periphery of a pattern element area, a light shielding portion which is formed by a semitransparent phase shifting portion and a transparent portion with the optimal size combination. A pattern is formed employing the semitransparent phase shifting mask.

ASA-481

United States Patent Application

for

PHOTOMASK AND PATTERN FORMING METHOD EMPLOYING THE SAME

by

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Fumio MURAI,

Katsuya HAYANO.

ASA-481-05

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Accompanying Continuation Application under
37 CFR 1.53(b):

Prior Application:	N. HASEGAWA et al Serial No. 08/904,754 Filed: August 1, 1997
Group Art Unit:	1752
Examiner:	S. Rosasco
For:	PHOTOMASK AND PATTERN FORMING METHOD EMPLOYING THE SAME

REQUEST FOR APPROVAL OF PROPOSED DRAWING CORRECTIONS

The Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

November 10, 1998

Sir:

The applicants request approval of the drawing corrections shown in red ink to make Fig. 4 consistent with the accompanying amendments to the specification.

Respectfully submitted,

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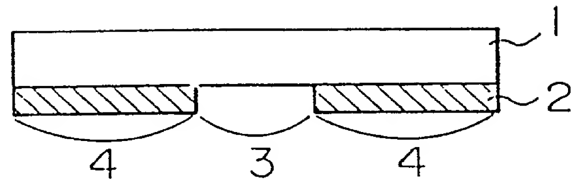
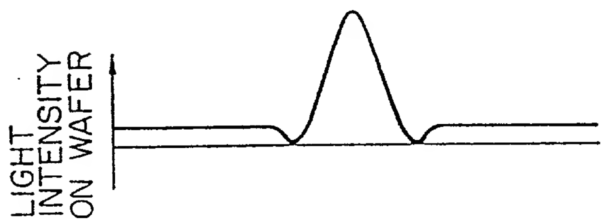
Date: November 10, 1998

F I G. 1A

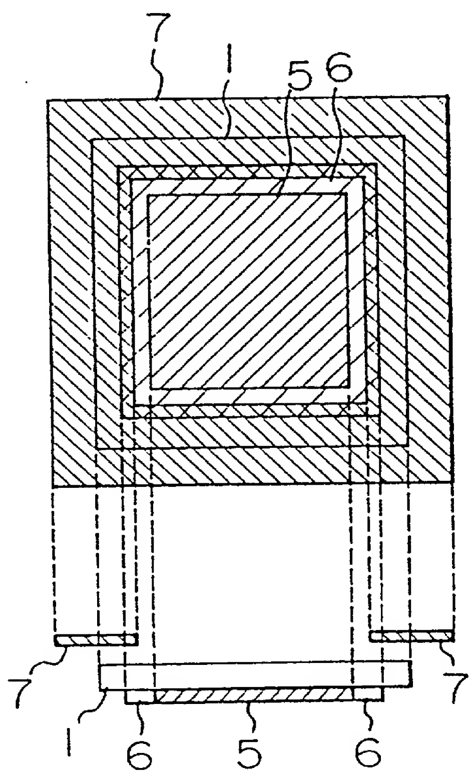


F I G. 1B



F I G. 2A

F I G. 2B



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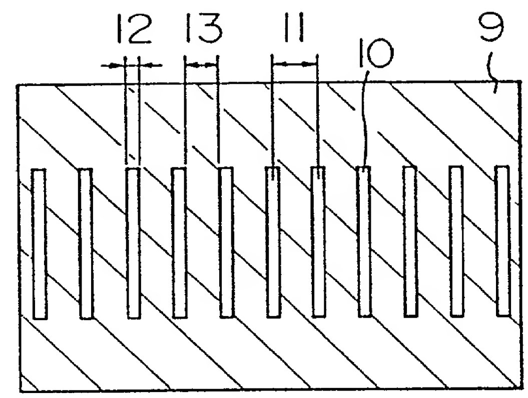
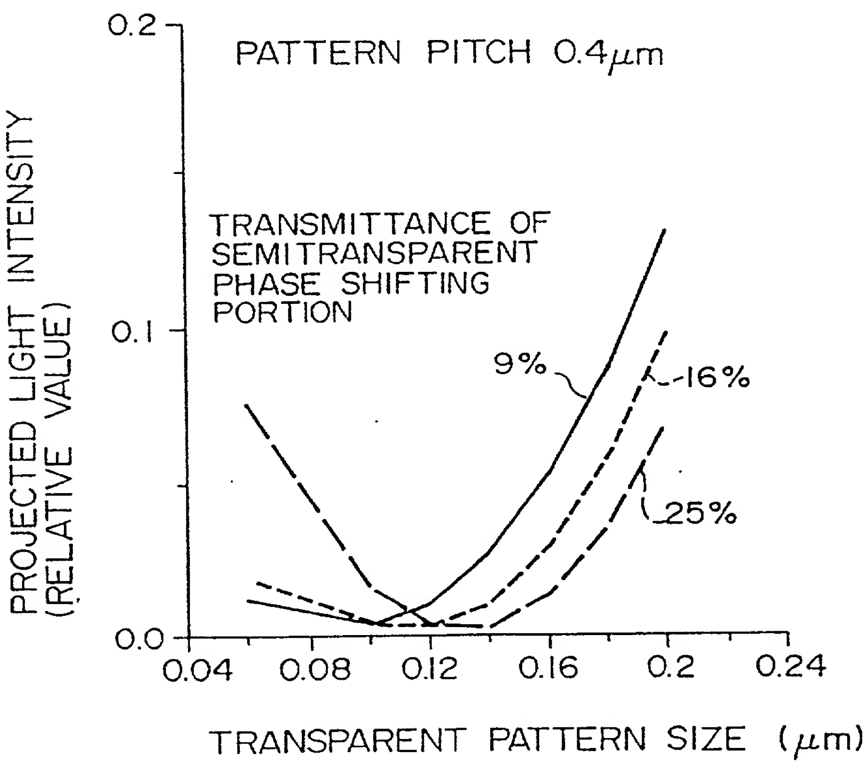


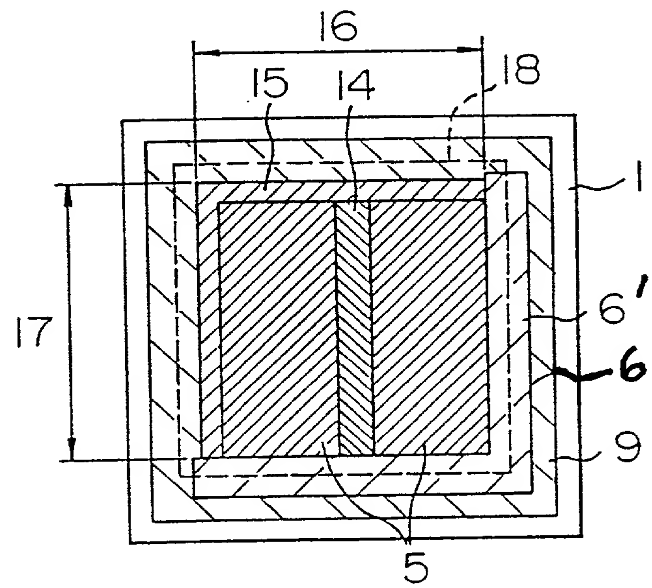
12
13
11
10
9

F I G. 3B

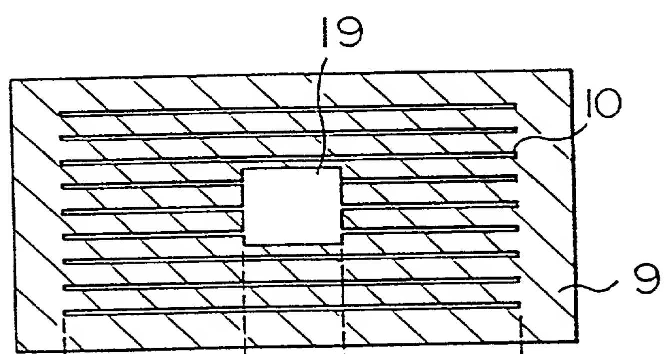


PATTERN PITCH 0.4μm
TRANSMITTANCE OF SEMITRANSPARENT PHASE SHIFTING PORTION
9%
16%
25%
PROJECTED LIGHT INTENSITY (RELATIVE VALUE)
0.2
0.1
0.0
0.04
0.08
0.12
0.16
0.2
0.24
TRANSPARENT PATTERN SIZE (μm)

F I G. 4

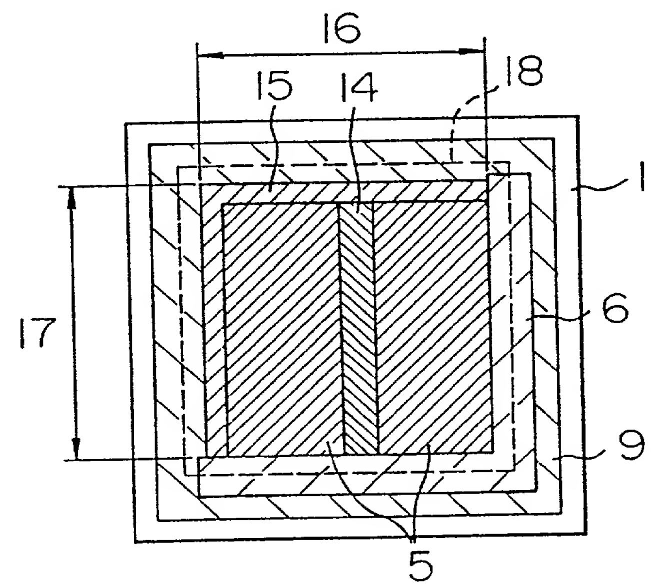


F I G. 5A

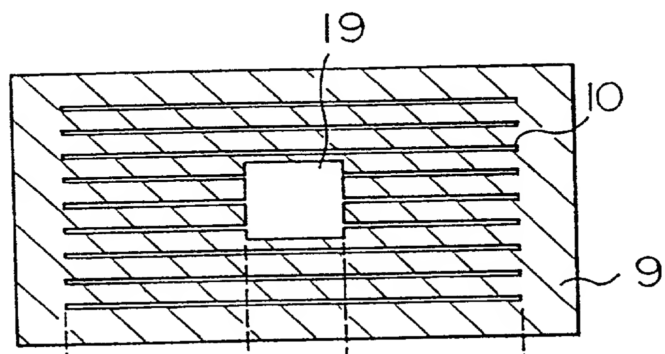


F I G. 5B

F I G. 4



F I G. 5A



F I G. 5B

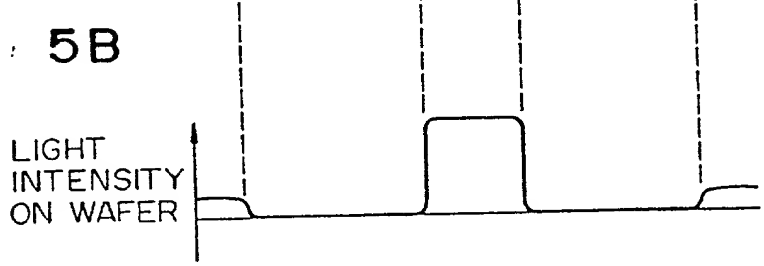


FIG. 6A

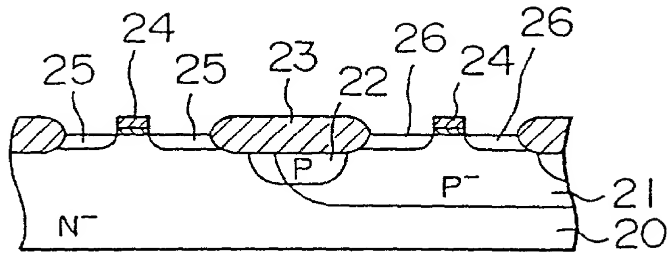


FIG. 6B

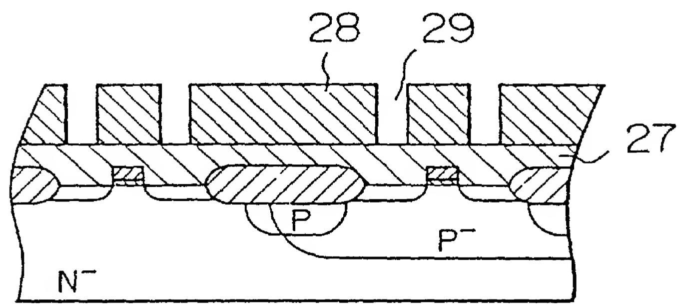


FIG. 6C

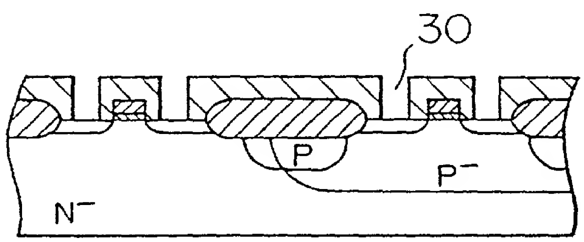
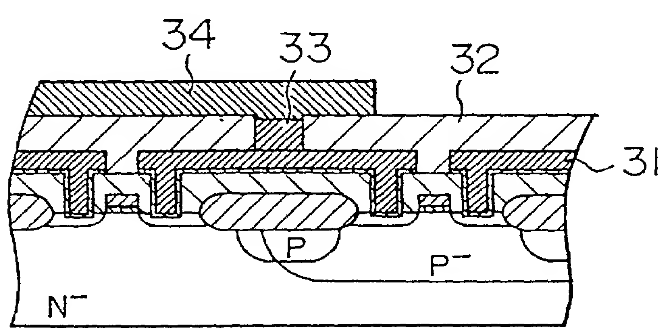


FIG. 6D



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COMBINED DECLARATION AND POWER OF ATTORNEY
(宣誓書及び委任状)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"PHOTOMASK AND PATTERN FORMING METHOD EMPLOYING THE SAME"

the specification of which: (check one) [X] is attached hereto.

[ ] was filed on ____________________
as Application Serial No. ____________________
and was amended on ____________________
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed:

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed Yes	Priority Claimed No
04-326433	Japan	7 Dec., 1992	[X]	[ ]
			[ ]	[ ]
			[ ]	[ ]

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to discolse to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

(Continued on Page 2)

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I hereby appoint the following attorneys/agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith and with any divisional, continuation, continuation-in-part, reissue or re-examination application, with full power of appointment and substitution of associate attorneys and agents, and to receive all patents which may issue thereon: Thomas E. Beall, Jr., Reg. No. 22,410; Roger D. Emerson, Reg. No. 33,169; Christopher B. Fagan, Reg. No. 22,987; Robert J. Fay, Reg. No. 16,921; John X. Garred, Reg. No. 31,830; Jeffrey M. Ketchum, Reg. No. 31,174; Richard M. Klein, Reg. No. 33,000; Thomas E. Kocovsky, Jr., Reg. No. 28,383; Sandra M. Koenig, Reg. No. 33,722; John R. Mattingly Reg. No. 30,293; James W. McKee, Reg. No. 26,482; Richard J. Minnich, Reg. No. 24,175; Jay F. Moldovanyi, Reg. No. 29,678; Philip J. Moy, Reg. No. 31,280; Timothy E. Nauman, Reg. No. 32,283; Patrick R. Roche, Reg. No. 29,580; Alan J. Ross, Reg. No. 33,767; Albert P. Sharpe, III, Reg. No. 19,879; John C. Tiernan, Reg. No. 21,078. Address all correspondence to: FAY SHARPE, BEALL, FAGAN, MINNICH & McKEE

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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